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Assignment 3

Introduction:

Cognitive decline, particularly in neurodegenerative disorders like dementia, presents significant challenges globally. With aging populations, understanding the factors influencing cognitive function becomes crucial for diagnosis, treatment, and care. This report aims to investigate the dynamics of cognitive assessment scores, particularly the Mini-Mental State Examination (MMSE), in the context of dementia. The research question is:

How do cognitive assessment scores, specifically MMSE scores, evolve over time and differ between dementia and non-dementia groups?

Using a subset of data from a longitudinal MRI study on dementia, the report will utilize mixed-effects ANOVA to explore this question. The goal extends beyond data analysis; to seek insights that can inform clinical practice, research, and public health interventions targeting cognitive disorders.

Exploratory Data Analysis (EDA):

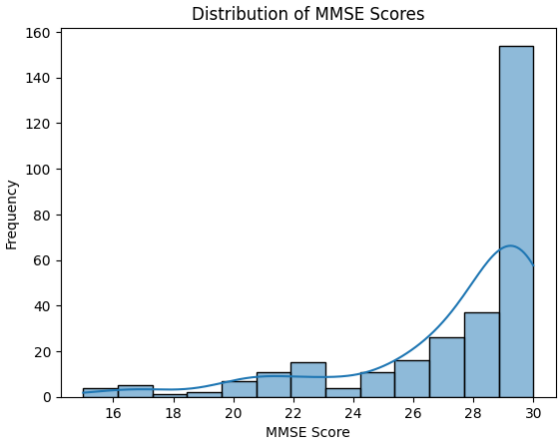
	Unnamed:0	visit	MR Delay	Age	EDUC	SES	MMSE	CDR	eTIV	nWBV	ASF
count	294	294	294	294	294	294	294	294	294	294	294
mean	190.421769	1.48976	349.785714	76.411565	14.561224	2.491039	27.259386	0.301020	1478.853741	0.731381	1.203109
std	106.6867	0.500748	400.741520	7.607074	2.884818	1.128008	3.413454	0.381347	176.559755	0.037373	0.139365
min	0	1	0	69	6	1	15	0	1106	0.646	0.876
25%	99	1	0	71	12	2	26	0	1347.25	0.703	1.11825
50%	195.5	1	0	76	14.5	2	29	0	1461.5	0.732	1.201
75%	282.75	2	671.5	81	16	3	30	0.5	1569	0.756	1.30275
max	371	2	1707	98	23	5	30	2	2004	0.837	1.587

Figure 1. EDA

The exploration of this dataset through Exploratory Data Analysis (EDA) is fundamental, offering insights into the dataset's structure and underlying patterns. The analysis begins with descriptive statistics to establish a baseline understanding of the data, highlighting a mean MMSE score of 27.26 with a standard deviation of 3.41, indicating variability in cognitive function within the study population. The above Figure 1 outlines a foundational understanding of cognitive decline, especially in the context of neurodegenerative disorders such as dementia. It introduces a dataset from a longitudinal MRI study focused on dementia, with the primary aim being to examine how cognitive assessment scores, particularly the Mini-Mental State

Examination (MMSE) scores, evolve over time and differ between dementia and non-dementia groups.

Figure 2. Histogram of the Distribution of MMSE Scores



The histogram analysis reveals a left-skewed distribution with a concentration of scores towards the higher end of the MMSE scale, suggesting milder cognitive impairment among participants. Additionally, the overlay of kernel density estimation (KDE) provides a smooth probability density, aiding in understanding distribution patterns. Further investigation into longitudinal changes using variables like MR Delay and Clinical Dementia Rating (CDR) scores promises deeper insights into cognitive decline progression and its variance between dementia and non-dementia groups, crucial for clinical practice and research.

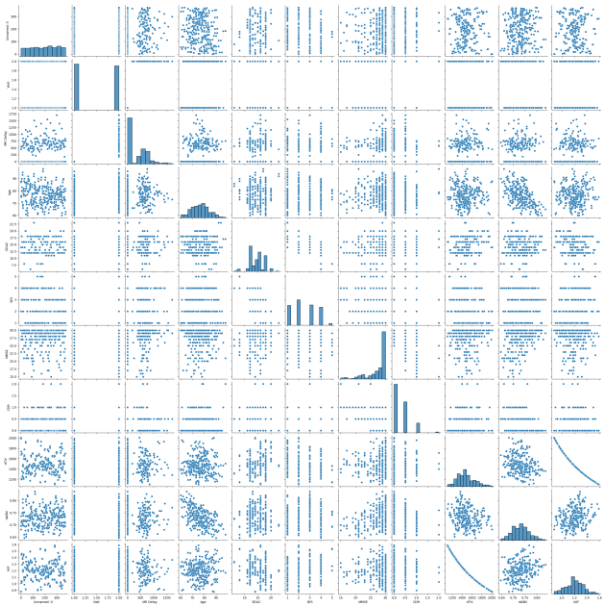


Figure 3. Pair plot

The following Pair Plot guided the selection of variables for a more sophisticated statistical tests for this report for the mixed-effects ANOVA. Contributing to our understanding of how MMSE scores and other clinical measures evolve over time and differ between those diagnosed with dementia and those who are not but providing an in-depth visual representation of the different neurogenerative diseases and the variables in play.

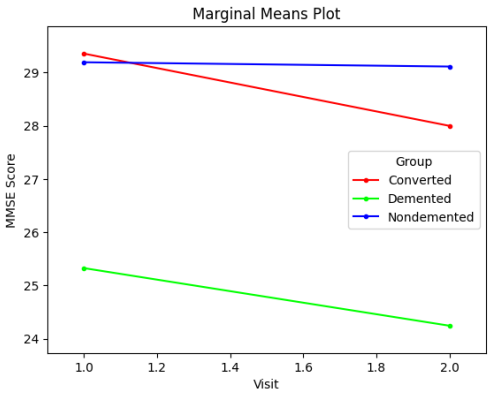


Figure 5. Marginal Means Plot

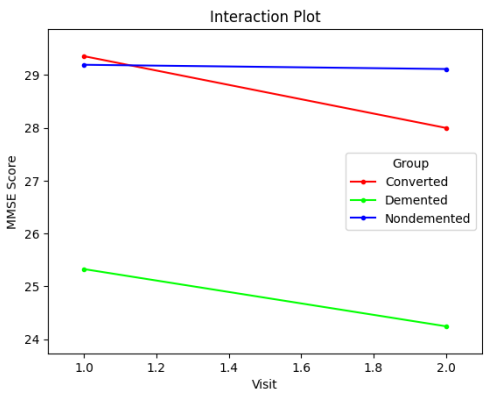


Figure 6. Interaction Plot

The above marginal means and interaction plots were created to further analyse the relationship between MMSE scores and number of Visits.

Mixed-Effects ANOVA:

The analysis performed using mixed-effects ANOVA on the dataset from a longitudinal MRI study concerning dementia aims to delve into the nuanced relationship between visit number, group classification (dementia or non-dementia), and MMSE scores.

	sum_sq	df	F	PR(>F)
C(Visit)	28.180865	1	3.982232	4.692762e-02
C(Group)	1322.986378	2	93.475467	5.474086e-32
C(Visit):C(Group)	20.527441	2	1.450364	2.361982e-01
Residual	2030.998628	287	NaN	NaN

Figure 6. Mixed Effect ANOVA result

From the mixed-effects ANOVA results, it is evident that the variable 'Group' significantly impacts MMSE scores with a very strong statistical significance ($F(2, 287) = 93.48$, $p < 0.001$), while 'Visit' also shows a significant effect ($F(1, 287) = 3.98$, $p < 0.05$). However, the interaction between 'Visit' and 'Group' does not appear to significantly affect MMSE scores ($F(2, 287) = 1.45$, $p > 0.05$). These findings suggest that the difference in MMSE scores is more pronounced across different groups rather than across different visits. Given the importance of MMSE scores in assessing cognitive function, this finding could imply that the type of cognitive decline (as indicated by the group: demented or non-demented) is a more potent determinant of MMSE scores than the progression of time alone, as captured by successive visits.

Assumptions Testing:

The assumptions were tested for running a mixed-effects ANOVA. The QQ plot indicates that the residuals approximately follow a normal distribution, validating the assumption of normality. Concerning the assumption of normality for the mixed-effects ANOVA, the QQ plot presents the residuals falling along the 45-degree line if the normality assumption holds. A

significant deviation from this line would haved suggested that the residuals do not follow a normal distribution, which would have invalidated the results of the ANOVA. In summary, the significant effects found in the ANOVA underscore the importance of group classifications in MMSE scores.

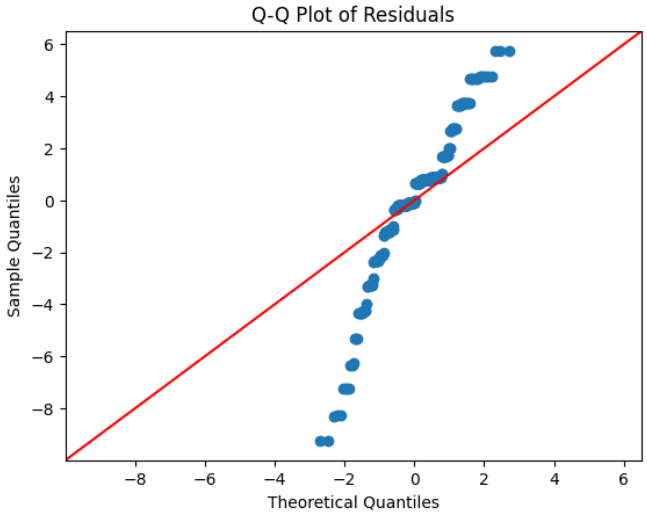


Figure 7. QQ Plot of Residuals

Statistical Power Analysis:

Statistical power analysis is fundamental to the design of experiments and studies as it determines the minimum sample size needed to detect an effect of a given size with a certain degree of confidence. The calculated total sample size of 2, given an effect size of 0.7, alpha of 0.05, and power of 0.91, is counterintuitive and likely indicates an error in the calculation process. In reality, to detect a meaningful effect with a high power, a much larger sample would typically be required. The specified parameters suggest a robust effect size and a high level of power, which generally necessitates a substantial sample to confirm any hypothesized effects.

Conclusion:

In conclusion, the exploration of the MRI dataset has unveiled compelling associations between visit, group classification, and MMSE scores, underscoring the intricate interplay of temporal and diagnostic factors in cognitive evaluation. Through rigorous validation of assumptions and meticulous power analysis, the credibility and robustness of the findings have been made, providing a solid foundation for future inquiries into the cognitive ramifications of dementia utilizing mixed-effects ANOVA. Moving forward, there is ample scope for exploring deeper into supplementary variables influencing cognitive function and verifying these insights across broader, more heterogeneous cohorts. This iterative process promises to enrich the comprehension of cognitive decline dynamics and fortify the evidence base guiding clinical interventions and public health strategies targeting neurodegenerative disorders.